

crease in the size of the flowers and the loss of pollen. With the loss of pollen the whole machinery of the two-armed levers, which had been so gradually acquired and so exactly brought the pollen on the back of the visiting humble-bees, has become useless and begun to abort, and, according to its new origin, this last abortion, as is shown by Figs. 123-129, still offers various gradations from the perfect mechanism to an insignificant little flap. In this gradual succession of more and more reduced stamens of *Salvia pratensis*, we find some forms (Figs. 125, 126) with a striking resemblance to the stamens of *Salvia officinalis* (Fig. 130), and some of the steps which

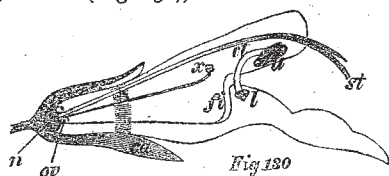


FIG. 130.—*Salvia officinalis*. Flower of *Salvia officinalis* bisected longitudinally.

are run through by this process of abortion seem to be quite analogous to those by which in former periods the stamens of *Salvia pratensis* have reached their astonishing singularity.

Briefly, the original five stamens of the flower have aborted at the following four successive periods:—

1. The uppermost stamen, in the ancestors of the family Labiatae (complete disappearance).
2. The two upper lateral stamens, in the ancestors of the genus *Salvia* (reduction to little knobs).
3. The two lower anther-cells of the two lower stamens, beginning to abort in *Salvia officinalis*; abortion and metamorphosis perfected in *S. pratensis*.
4. The two upper anther-cells of the two lower stamens, in the small-flowered plants of *S. pratensis* (abortion of the pollen perfected, abortion of the anther-cells and the whole stamens beginning).

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THE RESTORATION OF THE ANCIENT SYSTEM OF TANK IRRIGATION IN CEYLON

A WORK apparently pregnant with the largest and most beneficent results to the native population of Ceylon is in process of being carried out by the Colonial Government of that island. More than a thousand years ago a system of irrigation, the most complete and remarkable that the world has ever seen was in successful operation in the Low Country, and the object which the Government has in view is to restore to something like its pristine fertility a large proportion of the immense tracts of land—many hundreds of thousands of acres in extent—that for want of water have fallen into a condition of the most utter sterility. Sir Emerson Tennant, writing twenty years ago on this subject, says, "The difficulties attendant on any attempt to bring back cultivation by the repair of the tanks are too apparent to escape notice. The system to be restored was the growth of 1,000 years of freedom, which a brief interval of anarchy sufficed to destroy, and it would require the lapse of long periods to reproduce the population and recreate the wealth in cattle and manual labour essential to realise again the agricultural prosperity which prevailed under the Singhalese dynasties. But the experiment is worthy of the beneficent rule of the British Crown under whose auspices the ancient organisation may be restored amongst the native Singhalese."

The origin of the system of irrigation spoken of dates as far back as the year 504 B.C., when, according to the Singhalese Chronicle, Mahawanso, the first tank was built in the neighbourhood of his new capital, Anuradhapura, by Panduwasa, the second of the Hindu Kings.

This was succeeded about seventy years later by two others formed in the same neighbourhood. In the year 459 A.D. the Kalawewe Tank, the largest of all, was completed. The retaining bund of this immense sheet of water is twelve miles long, and the circumference of the lake which it formed was no less than forty miles, the water being backed up for a distance of fifteen miles and conducted from the tank by means of a conduit sixty miles in length to the capital. Sir Emerson Tennant in describing these remarkable reservoirs, says, "Excepting the exaggerated dimensions of Lake Moeris in Central Egypt, which is not an artificial lake, and the mysterious basin of Al Aram in Arabia, no similar constructions formed by any race whether ancient or modern exceed in colossal magnitude the stupendous tanks of Ceylon." The same author estimates that at the time of its greatest prosperity the island contained a population of from fifteen to twenty millions, nearly all of whom must have derived their means of sustenance from irrigated lands. At the present moment, after all the care bestowed through three-quarters of a century by a paternal government, the population only amounts to 2,400,000, whilst even for this a large proportion of the food—6,000,000 bushels of rice annually among other things—has to be imported from India, and the population itself must be considered to have been somewhat unnaturally increased during the last fifty years by the stimulus of European enterprise. The mass of the people too have changed their place of residence from the interior to the neighbourhood of the sea-coast, where trading and fishing instead of rice-cultivation furnish them a livelihood. The vast areas which formerly under the magic influence of a sufficient supply of water and a hot sun, produced their two or three crops of rice in a year are now absolutely deserted, frequently not a single inhabitant surviving where once a thousand found ample means of subsistence. The city of Anuradhapura, if its ruins afford us any means of estimating its magnitude, must have covered an immense area—no less than from thirty to forty square miles, and the population living on the spot and drawing its supplies of food from the immediate neighbourhood must have been correspondingly immense. Now it is a mere village in the midst of vast heaps of ruins.

One of the most gigantic of these early irrigation works is supposed to have been originated by Maha Sen about the year 275 A.D., and, having been enlarged by Prakrama, Bahu I., who reigned in 1153, to have received from him the name of "The Sea of Prakrama." It consisted of a series of lakes formed by an embankment twenty-four miles in length and from forty to ninety feet high, by which the water of a large river and many considerable streams was hemmed in along the base of a range of hills and so forced into the valleys that a series of lagoons or lakes was formed extending for the above-mentioned distance and frequently several miles in width. A canal five miles in length conducted the waters of "the sea" to the Minery Lake, another of the works of Maha Sen, to be mentioned presently, and a further canal from Minery led the waters to the neighbourhood of Trincomalie, in all a distance of fifty-seven miles. When it is remembered how sudden and torrential the rains are in a country like Ceylon—the writer has known 18 inches of rainfall in forty-eight hours over a very large extent of country, and at one spot as much as 18½ inches in twenty-four hours,—we cannot too much admire the vastness of such a work and the skill which enabled the native engineers to use the natural features of the country in such a manner that for a distance of twenty-four miles a single embankment sufficed not only to hem in the water for purposes of irrigation but also to provide a water-way for the transport of produce and merchandise. Along the whole course of this embankment and canal and wherever its tributaries carried the life-giving water there would be without doubt a teeming population; for irrigable land in

Ceylon is capable of supporting, according to official calculation, 1,000 persons to the square mile. In 1855 there was not a single inhabited village, although a few patches of land were occasionally cultivated by people from a distance. The contrast between the remote past and the present condition of this half of the island is a painful one to contemplate, but it is to be hoped that the Colonial Government will never stay its hand until all the useful works of ancient times have been restored and improved—but this will be a work of centuries.

Long before the Christian era the main ambition of the kings of Ceylon appears to have manifested itself in the formation of tanks, and many kings are mentioned in the Mahawanso who, "for the benefit of the country," and "out of compassion of living creatures," built a dozen or more of these splendid, but absolutely necessary, irrigation works. The Minery tank, some twenty miles in circumference, and irrigating an enormous area of fertile land now entirely barren, owed its origin, along with sixteen others, to Maha Sen, who reigned about the year 250 A.D. It is now merely a swamp, resorted to by enormous numbers of wild fowl. Up to the twelfth and thirteenth centuries Ceylon produced her own supplies of food, but in the fourteenth it appears that the island was obliged to import a portion of it from India. In 1301, it is related that there were 1,470,000 villages in Ceylon. In 1410, as many as 1,540,000, the term village implying hamlet, or even a single house where there are people resident. Of the vast majority of these, if they ever really existed, not a vestige is left except the ruined tanks, which show unmistakably where the foci of population formerly were. This was shortly after the conquest of the island by the Malabars, who are believed not to have actually destroyed the fabric of the embankments, but by their system of government to have disorganised the village communities to such an extent that the works connected with the tanks fell into disrepair through neglect, the land became imperfectly irrigated, and the population gradually died out. That this process was a perfectly natural one seems evident from the fact that the tanks do not show any traces of wilful damage, and also from the consideration of the almost innumerable evils resulting in death, of which a scarcity of water in a tropical country like Ceylon is productive. Indeed one of the most frightful diseases that have ever scourged the human race is believed to have been developed in these very localities chiefly through the want of proper food, caused by the absence of a system of irrigation. It is believed, too, and there is strong evidence, based on experience, for the belief that the disease entirely disappears wherever irrigation is restored. It will naturally be asked, "If the advantages of a plentiful supply of water are so enormous, why have not the tanks been restored before this, and what hinders their immediate restoration at the present time?" The reply is, that the creation of this magnificent system of irrigation was not the work of a decade, or even of a century, but of a thousand years of successful national development, and that therefore the restoration of it must be also a work of time.

The object of this paper is to draw attention to the fact that the experiment of restoration is at the present moment in process of being tried, and bids fair, after the lapse of half a century or so, to alter entirely the character of the island. The most remarkable success has already attended the efforts to afford irrigation facilities to the Singhalese on the East Coast. Where but a few years ago the natives were half-starved and the land apparently in a hopeless condition, the re-introduction of irrigation through the assistance of the Government, has transformed not only the people, but the country, as if by magic. Rice-fields, palms, and other fruit-trees abound, and the population is increasing at a rapid rate. Of this particular district the present Governor of Ceylon (Sir William Gregory), reported some four years ago to the Legislative

Council of the island in the following terms:—"In the month of April I visited the rice-growing regions of the Eastern Province, which are the creation of the irrigation works carried out by the Government. I never before saw such an unbroken sheet of grain. Save where some isolated trees, part of a recent forest broke the view, the eye wandered over some 20,000 acres of green paddy. I saw, wherever I went, a sleek, vigorous, well-fed, and thoroughly healthy population. Up to 1864 the lands under cultivation in this province were 54,000 acres, the chief impetus to the irrigation scheme having been given in 1857. In 1871 the lands in cultivation were 77,000 acres. The Crown lands to be additionally reclaimed under works already completed or in course of completion, amount to 15,900 acres, equal to the support of 23,850 persons." Again, speaking in the same report on the subject of the Great Tank already mentioned, he says: "I am most anxious to put the full strength of the department at work in restoring irrigation to Nuwara Kalawia. This magnificent district has the strongest claims upon us. It was once the granary of the island. It is now utterly neglected. It has a population of 60,000 persons and over 1,600 villages, which have each of them their tank. There are at least 1,700 of these tanks, and I am credibly informed not one of them has a sluice in order. I trust that a few years hence the population may present the same vigorous and thriving appearance as the population of the Eastern Province, and from the same causes—namely, good and plentiful food." Of this same district a gentleman of very great experience told the writer that in travelling through it many years ago he came to a village where, of the thirty inhabitants, only one of them was able to carry water, all the others having been stricken down by hunger or disease. This destitution was caused by the failure of three successive rice-crops, and was not specially exceptional, but fairly representative of what takes place frequently in the district. If we compare the scenes of plenty and contentment as they exist in the Eastern Province at the present moment with what meets us in the Wanni, or in any of the northern districts, where tanks have not been extensively repaired, the contrast is most striking. We find an almost depopulated country, with here and there a wretched village peopled by a few miserable and more than half-starved inhabitants, who, in times of scarcity, which are not infrequent, are obliged to live on roots and wild herbs, who are periodically decimated by a frightful disease, yet who seem bound to the spot where they were born, and prefer to die there rather than move away to a more fertile and healthy district. It is, indeed, this disinclination which possesses the agricultural Singhalese to move more than a day's journey from his home that presents the greatest of all difficulties to the scheme for the restoration of the tanks. It is on this account that the process of restoration is always in advance of the supply of natives to take up the new land, unless the works happen to be in the immediate neighbourhood of population. The only plan, therefore, that has proved really successful under present conditions is to restore the tanks in the vicinity of villages, and induce the population to creep slowly onwards step by step, cultivating the more fertile pieces of ground as it advances, until the depopulated districts shall have been partially reclaimed, when the completion of the work will be a matter of comparative ease. Two typical instances of this mode of procedure have been mentioned to me by an official high in the Government service, as showing the effect of a well-regulated expenditure of labour and money in restoring irrigation works. In the year 1854 Mr. Bailey, whose name will ever be associated with this scheme for benefiting the natives, spent less than 100*l.* on a canal some miles to the north of Matalé, a country town a few miles north of Kandy. The village thus supplied with water had previously dwindled away until only three houses

were left, the rice-fields were deserted, and the famine-stricken inhabitants declared that they would die where their fathers had lived and died rather than migrate to a part of the country that was unknown to them. Ten years after the improvement was made the spot had become a little oasis in the desert; nearly 200 acres of rice were under cultivation, yielding about thirty bushels per acre, and supporting a population of several hundreds.¹ Almost in the same neighbourhood a sum of between 200*l.* and 300*l.* was spent on an old canal fifteen miles in length by the same zealous Government official already mentioned. Many hundreds of acres were brought under cultivation, and in ten years' time, instead of a starved and fever-stricken population of 150 inhabitants, no less than 500 able-bodied men were on the list as liable to the road-tax. The changes in these, as in other instances, took place as if by magic, yet the means employed in effecting them were of the most limited and simple nature. The secret of the success lay in the fact that a famishing and disease-smitten population was within a few miles of the spot, and the remnants of ancient engineering skill were ready at hand to guide the labourers on to certain success. Since the above tentative experiments were made, very great changes for the better have taken place in the condition of the agricultural part of the native population. The carrying out of the scheme for the restoration of irrigation works is recognised as one of the chief duties of the Colonial Government, and there is little danger that, after the real success which has attended it so far, any future Government will allow it to be interrupted. The policy of the Colonial authorities may be summed up in the pregnant words of Sir Wm. Gregory's address to the Legislative Council in 1876:—"I consider that at least 100 tanks should be supplied with sluices, and properly repaired each year; and I have asked the Secretary of State to furnish me with an additional number of well-trained officers, by whom these works will be carried on with vigour. There is no boon which the Government can confer on the villagers more legitimately than this. It is a reward for their own exertions, and I am confident that each year, as it becomes better understood, it will be more appreciated, and that it will be recognised everywhere that the Government have no other object in it than to increase the comfort and resources of the people." It will appear, from what has been quoted, that the tanks are not repaired free of cost and then handed over gratuitously to the villagers, but the natives are required to give a certain amount of labour in restoring the tanks, and also to pay a small rent or tax on the land cultivated, so that, whilst the native cultivator is the chief gainer by the undertaking, the Government is no loser. If there could have been a doubt as to the wisdom of the Tank Restoration scheme, the experience of the last three years must have dispelled it and proved how absolutely necessary a system of irrigation is to the welfare of the natives. In the address above quoted, whilst speaking of the cholera and other diseases which had visited several of the provinces, the Governor says:—"It is remarkable that the inhabitants of the Eastern Province enjoyed perfect immunity from epidemics of all kinds. It is an interesting question, on which I do not give an opinion, whether this general immunity from disease in the Eastern Province is due to the abundant supply of food throughout the populous part of it, the result of irrigation works." At the same time he speaks of the restoration of two of the large tanks as complete. One of these will irrigate 23,000 acres, equal to supporting a population of 35,000 persons; the other will bring large tracts of magnificent land into cultivation, and dissipate the unhealthyness of the district which has hitherto prevented settlement.

¹ Irrigated rice-lands in the low country will support population at about the rate of 1,000 persons to the square mile.

To look back over the early history of the attempts under Sir Henry Ward to restore the above system of irrigation, is like reading the accounts of the commencement of a successful campaign. The difficulties encountered were sufficient to discourage even enthusiastic philanthropists, chief amongst them being the utter disorganisation of the village communities through the abolition of compulsory labour and the rooted dislike of the natives to migrate from one spot to another. For the recent part of the evil caused by this disorganisation the British Government was alone to blame, for in abolishing *Rajekaria* they abolished the right of compelling villagers to keep their tanks and watercourses in repair. By doing this they practically placed the distribution of the most valuable property of which the natives were possessed in the hands of the strongest, and consequently the most unscrupulous, inhabitants of each district. In a dry season, when there was barely sufficient water to irrigate the fields along the course of a canal, those who were nearest to the source of supply would probably get more than their share, whilst those who were furthest from it and had an equal claim on it might get none; but, generally, the strongest party would get the advantage, to the ruin of the weaker. Dams would be built at various points along the course of the stream by one party, and as quickly destroyed by another. Interminable feuds were the results, and appeals to the courts of law, which, not being guided by native customs, only made matters worse. The canal, too, which ought to have been kept in proper repair by the united efforts of all who benefited by it, was allowed to fall year by year into a more ruinous condition, after compulsory assistance had been abolished, the residents on the upper portion of it refusing to aid those on the lower to repair the breaches made by the annual floods. Consequently the work that was done was ill done, and only of a temporary character. Soon it became beyond the power of isolated communities to effect the necessary repairs; the lands fell out of cultivation, and the population, after a long struggle with their neighbours, either died out or sought a living elsewhere. The early legislation in 1856 was based on a revival of the native customs and a compulsory distribution of the necessary work among the different villages, a majority of two-thirds of the inhabitants being enabled to place the lands under the Irrigation Ordinance, and to compel the assistance of all who benefited by the supply of water. The scheme resulted in complete success. It met the great want of the natives and the interminable disputes about boundaries and rights of water, which was as much property to the natives as the land itself, soon ceased. The Government claimed its own and sold large portions of it by auction at a very reasonable rate, the upset price being generally 1*l.* per acre, the land continuing to be chargeable with a yearly tithe to the Government of from 3*s.* to 4*s.* per acre. In special cases the Government granted even easier terms in order to induce the natives to settle in particular localities. Newly-purchased land was allowed to be free from tithes for four years, and the purchase-money was spread over an equal period from the time of sale. The pecuniary result was most gratifying to the Government, and the benefit conferred on the natives inestimable.

A few words will be sufficient to describe the character of the cultivation which this system of irrigation is intended to promote. A crop of rice, or paddy, as the undressed grain is called, requires about ninety days to come to perfection, and during this time it must be supplied with about thirty inches in depth of water, or a little over 4,000 cubic yards to the acre. The first and second watering of the paddy takes place within a fortnight of the sowing of the seed, and the water is only allowed to remain on the land for a short time. The three subsequent waterings take place about the twentieth, the

fortieth, and the sixtieth days after sowing, from eight to ten inches of water being used each time, and the water is allowed to remain on the land until it has evaporated. This system, though more or less modified according to the climate and the supply of water, is fairly representative of rice-cultivation in the lowlands of Ceylon. The official estimate of the produce is about thirty bushels per acre. It is probable that exactly the same system existed in the very earliest times, and that the Singhalese engineers were able to regulate the flow of water through the tank sluices just as they wished. It certainly seems unreasonable to suppose that the men who could design such a vast irrigation system with no better means of levelling than that of leading water by actual experiment from one point to another, should fail in minor matters such as sluice-gates. Yet the writer believes that nothing is known as to the manner in which the flow of water was regulated. It is true that in some of the sluices a square masonry well is found leading upwards from the sluice soon after it has entered the embankment from the tank, but there is nothing left to show how it was used. Captain Sim, R.E., some years ago suggested that it was intended to break the force of the water rushing in flood-time towards the sluice and reduce the velocity of the water in the sluice to that due to the pressure in the well only. I am however inclined to think that a frame of wood somewhat in the shape of a box strongly braced together was fitted into the well so that it could rise and fall readily under the influence of the water in the tank, and that by placing weights on the top the frame might be forced down so as to cut off either partially or wholly the water issuing through the sluice. Wherever rocky foundations could be found for a dam or a ledge of rocks for a spill-water, the native engineers, as if distrusting artificial constructions, would be sure to utilise them. In some cases, where it was possible to include masses of rock in the embankment, the sluices themselves would be cut out of the solid gneiss and the work thereby rendered as indestructible as the rock itself.

It will no doubt be somewhat surprising to persons who are only acquainted with the system of rotation of crops in vogue in Europe, that these rice-lands can be made to produce year by year for hundreds of years consecutively, one or two crops of grain annually without the land becoming exhausted or requiring to be continually renovated by manure. The explanation, however, seems to be that sufficient vegetable matter is carried down from the hills partly in solution and partly in suspension in water to supply all the waste produced by the continuous cropping. Those who have visited the richest alluvial valleys of California and Australia will no doubt have been struck by the fact that the most fertile soil is always found where the alluvium has been deposited in extremely fine particles and in water practically at rest, conditions which obtain in the paddy fields of Ceylon, and must have obtained formerly on the Hunter River in New South Wales, and in the valleys opening on the Bay of San Francisco.

I cannot better conclude this paper than with an extract from a minute by Sir Henry Ward, after a tour of inspection in 1859:—

"The village of Samantorre is a very fine one, and stands on the borders of the richest plain in Ceylon, containing, as it does, nearly 15,000 acres of paddy. Mr. Birch and Mr. Cumming informed me that the scene of joy and excitement exhibited by the whole population when the water first came down from the Ericammam, in July, 1858, and saved a magnificent crop from destruction by drought, was one of the most striking things ever witnessed. Hundreds of people had collected at Samantorre as soon as they knew that the sluices were to be opened; and when the water was actually seen advancing down the bed of the dried-up river, the shouts, the firing of guns, the screams of the women, the darting off of messengers bearing the news in every direction,

made a deep impression on all who saw it. They felt that a great work had been done, a great benefit conferred. But I feel also that under British rule this benefit ought to have been conferred thirty years ago upon a people so capable of appreciating it. Indeed, knowing what I now know of the history of the Eastern Province, I hold that what the Government is doing in 1859 is simply the payment of a debt incurred by our rash interference with a people of whose habits and wants we knew nothing. This error is now in part repaired. 44,000 acres of land are already under paddy cultivation, and I see reason to believe that the amount will be not less than 60,000 acres in 1861, when the irrigation works have obtained their full development. But this will require constant attention on the part of the Government and of its local representative. The maintenance of the system must never be lost sight of, and should unforeseen demands for assistance arise they must be met liberally and promptly." The words of so successful a governor have not been forgotten. The present governor, Sir William Gregory, has devoted all his energies to the carrying out of what was so well begun. The survey and engineering staff of the colony has been considerably increased, and the restoration of nearly the whole of the ancient irrigation works, besides the creation of new ones, may now be considered to be only a question of time.

R. ABBAY

NOTES

THE *Times* devoted a leading article last Thursday to Mr. Forster's remarkable speech at Bradford, in which he attempted to indicate the latest ideal of what elementary schools and universities ought to be. The *Times'* summary of the points of Mr. Forster's address is very satisfactory. "Mr. Forster's notion of a public elementary school is very unlike that which has been commonly entertained. The school is to be for the benefit of all classes. All subjects are to be taught at it, with no other limitation than such as may be imposed by the wants or capacity of the scholars. The secondary school is to supplement the teaching of the primary school, and to do for boys of a more advanced age the same sort of work which the primary school has done for them up to the age of thirteen or fourteen. That science should be introduced as a regular part of the school course is, in Mr. Forster's opinion, most desirable. History and geography he considers, indeed, as of even greater importance than science, but he places the claims of science above those of grammar, and seemingly above those of the study of language in any form. He is very hopeful that the older universities will consent to model themselves on the plan he suggests, and to grant degrees for science without insisting on Greek and Latin in addition to it. If they will not do this, or if they are very long about it, he will look to younger bodies, untrammelled with literary traditions, to take their place in this matter. What Oxford and Cambridge may refuse, Manchester and Leeds will make no difficulty in granting, and a combined university for the North of England is to be set up accordingly and invested with the necessary powers." The *Times* does not seem to know very well its own mind on the subject referred to by Mr. Forster. It clings to the old ways, and virtually confesses that the new ways are as indispensable as the old, that some knowledge of science is now indispensable to all. Mr. Forster declares we have no right to erect Board Schools and compel children to attend them, only to give them a smattering of the three R's. The purpose of these schools—which he, with many others, thinks ought to be open to all classes, and afford an elementary education which would be considered adequate by any class—is to fit the children who attend them to make a fair start in life, and in this scientific age, as the *Times* virtually admits, no one can be said to have a fair start if he be ignorant of at least some of the results of science. Mr.